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METHOD ANALYSIS ON INCREASING THE MECHANICAL RESISTANCE OF THE FIRING PIN SPRING IN THE FIRING LOCK OF THE 152 MM CALIBER HOWITZER

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Abstract: *The authors of this scientific paper wish for highlight, experimentally and analytically, the possibility of constructive optimization of the compression-loaded firing pin spring within the organological assembly of the closure mechanism for the 152 mm caliber howitzer MD. 1981. Modifications were made to the winding angles of the spring during a constructive optimization that implicitly increased its resistance, leading to analytical and graphically characteristic curves rendering the progress of specific constructive parameters.*
Key words: *experiment, cylindrical helical spring, compression, constructive optimization.*

1. INTRODUCTION

The military environment, constantly and permanently changing, must align with current imperatives regarding initiatives to ensure technological balance applied to military technologies, particularly in the field of artillery, aimed at protecting the human factor and enhancing the capability of the armed forces. In order to meet the needs in the educational sphere, by fostering highly educated and specialized human resources through academic studies, intended to cope with the diversity of current operations and challenges, artillery weapons must improve their mobility, operational flexibility, and protect the human factor during their use. [1]

The present scientific paper highlights the possibility of constructive optimization (aiming to increase operational resilience) of the compression-loaded firing pin spring within the organological assembly of the closure mechanism (fig. 1 a)) for the 152 mm caliber howitzer MD. 1981. In this regard, the authors of this scientific endeavor have imposed, on the one hand, modifications related to the winding angles of the spring, obtaining through analytical, experimental, and graphical methods characteristic curves depicting the evolution of particular structural parameters associated with the element being studied, and, on the flip side, consideration was given to the possibility of modifying the coil diameter to achieve constructive optimization of the spring for enhancing its operational resilience.

2. EXPERIMENTAL AND STATIC ANALYSIS OF THE CYLINDRICAL HELICAL COMPRESSION SPRING

Materials with well-defined properties are necessary for the functional characteristics of springs, such as: high yield strength, high resistance, fatigue resistance, and high temperature plasticity. [2]

To determine the stresses and strains in the helical compression spring, a quarter of a spring coil is considered (Fig. 1 b), c)).

Based on the winding angle α, the firing pin spring was analyzed both Mathcad® software for verifying experimental analysis and applying compression load to the spring on the Quasar 25 kN column testing machine (Fig. 2).

This was done considering the dimensional elements of the spring coil: R_m = 19 mm; n = 13 spire; α = 6 degrees – 90 degrees; D=21 mm; p_h=3 mm; d($g_{sp.}$)=3,5 mm, h=77 mm; G = 8200 - 8250 daN/mm^2, F= 20 N,

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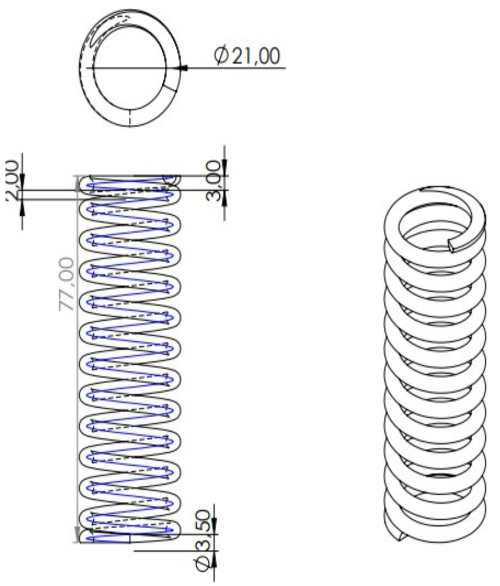
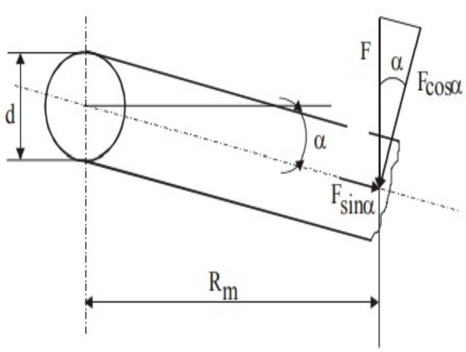
i = 2R/d =2·5,9/3,5 = 3,71→ 4 (spring index), d=3,5 mm (38Si7 stainless steel spring according to V2A 1.4310 catalog). [3], [4].

a) firing lock [7]



b) firing pin spring



c) geometry of the quarter spring [5], [6]

Fig. 1. Elements subjected to analysis

By decomposing the force F acting along the axis of the circle, both analytically and graphically, it follows [5], [6]:

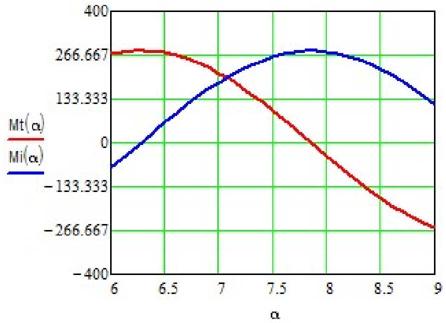
- torsional moment: $M_t = F \cdot R_m \cdot cos\alpha$; (1)
- torsional moment: $M_t = F \cdot R_m \cdot cos\alpha$; (2)
- bending moment: $M_i = F \cdot R_m \cdot sin\alpha$; (3)
- shear force: $T = F \cdot cos\alpha$; (4)
- tensile force: $N = F \cdot sin\alpha$ (5)

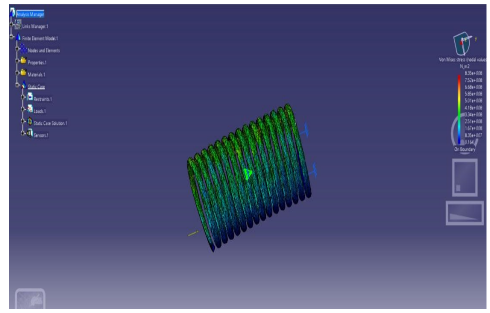
By varying the winding angle of the spring within the range of 6,51 degrees – 9 degrees, it is possible to optimize and calculate the strength parameters of the material under consideration (bending moment, torsional moment, tensile force and shear force) as exemplified in the graphs and tables presented below (Fig. 3 a), b)).

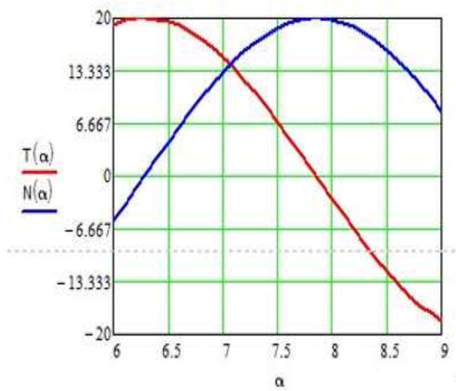
Fig. 2. Firing pin spring subjected to compression load

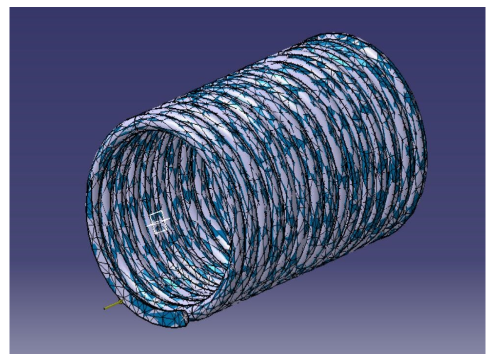
$Mt(\alpha) =$	$Mi(\alpha) =$	$T(\alpha) =$	$N(\alpha) =$
268.848	-78.236	19.203	-5.588
275.315	-51.006	19.665	-3.643
279.032	-23.265	19.931	-1.662
279.96	4.708	19.997	0.336
278.092	32.634	19.864	2.331
273.445	60.234	19.532	4.302
266.065	87.232	19.005	6.231
256.027	113.358	18.288	8.097
243.431	138.352	17.388	9.882
228.403	161.963	16.315	11.569
211.093	183.956	15.078	13.14
191.673	204.111	13.691	14.579
170.338	222.227	12.167	15.873
147.302	238.122	10.522	17.009
122.793	251.638	8.771	17.974
97.058	...	...	...
70.353			
42.945			
15.108			
-12.881			
-40.74			
-68.192			
...			

a) analytical results

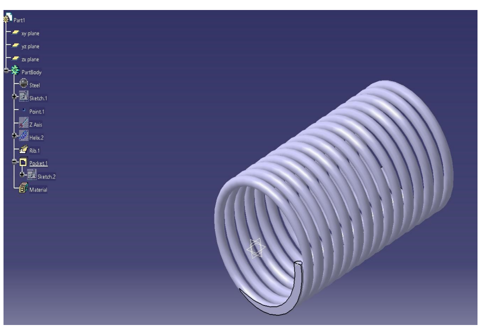


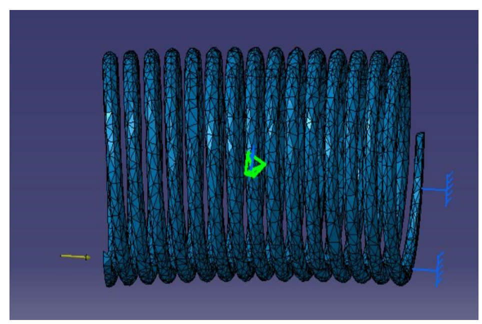






b) graphical results





c) analysis with FEA

Fig. 3. a), b) Analusis graphs of M_t, M_i, T și N; c) FEA analysis

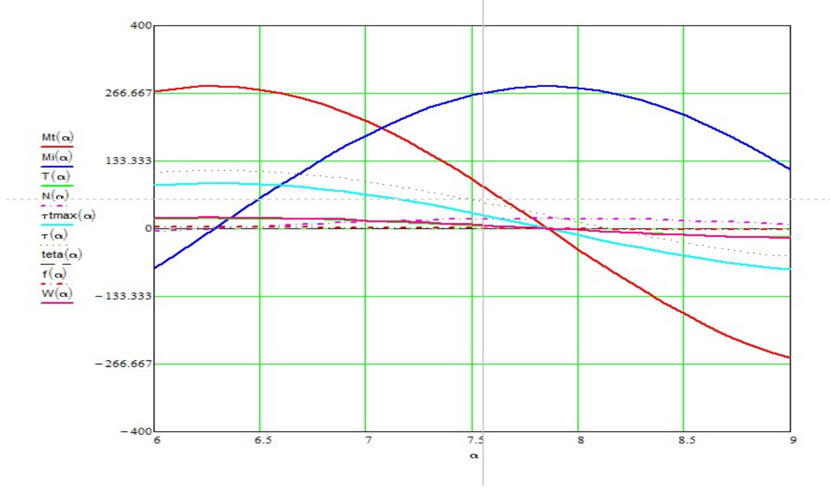


Fig. 4. Centralization of graphic interpretations

3. FINAL CONCLUSIONS

The conclusions stemmed from analytical and experimental dates should be interpreted such (Fig. 3 a), b) and Fig. 4):

a. at a minimum wrap angle of α=6 degrees, the torsional moment reaches its maximum value, M_t=267 Nm, and with a progressive increase in the angle towards the maximum possible, the torsional moment decreases progressively following a convex parabolic trajectory;

b. at a wrap angle of minimum α=6 degrees, the bending moment maintains a minimum value of approximately M_i=-67 Nm, and with an increase in the angle towards α=8 degrees, the bending moment reaches a maximum jump of M_i=267 Nm, and then decreases slightly following a trajectory resembling a convex parabola;

c. the cutting force has a maximum value of T=20 N for a minimum angle of α=6°, and with a progressive increase in the angle, the cutting force also decreases linearly;

d. the tensile force is minimal and linear for a chosen angle of α=6 degrees, and for angles between 7 degrees and 8 degrees, the force increases to a maximum value of N=20 N and will decrease to T=6,70 N for angles between 8,5 degrees and the maximum value of 9 degrees.

From the finite element analysis of the cylindrical compression spring, it emerges that the maximum equivalent stresses are found in the inner area of the coils, confirming the anticipated analytical results (Fig. 3 c)). Numerically, the maximum value of the Von Mises equivalent stress (124 MPa) is lower than the allowable compression strength τ_{at}=665,1 MPa, the main loading condition of the spring. This confirms the resistance of the spring to this type of loading, with the structural optimization allowing for better performance within the closing device.

4. REFERENCES

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Metoda experimentală privind creșterea rezistenței mecanice a arcului percutor din componența închizătorului la obuzierul calibrul 152 mm

Rezumat: Autorii acestei lucrări științifice doresc să evidențieze, experimental și analitic, posibilitatea optimizării constructive a arcului percutor solicitat la compresiune din cadrul ansamblului organologic aferent mecanismului de închidere al obuzierului calibru 152 mm MD. 1981. Urmărindu-se o optimizare constructivă a arcului luat în studiu și implicit, o creștere a rezistenței acestuia, s-au impus modificări a unghiurilor de înfășurare ale acestuia, obținându-se grafic și analitic, curbe caracteristice care redau progresul anumitor parametri constructivi ale elementului studiat.

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